Federal Office of Metrology and Surveying

The Vienna VLBI contribution to the ITRF2020

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Abstract

In the course of preparation of the ITRF2020, the Federal Office of Metrology and Surveying (BEV) has created together with TU Wien one of the VLBI solutions combined by the Federal Agency for Cartography and Geodesy (BKG).

VLBI analysis centers usually model the Earth orientation parameters (EOP) as offsets and rates. However, the Vienna solution uses piecewise linear offsets (PWLO) to model the EOP and is the only analysis center that has also submitted these for combination. After some initial problems the solutions could be combined successfully.

This poster will discuss the creation of this solution. Specifically, the parameterization of the EOP will be described in more detail. Furthermore, the finished Vienna VLBI TRF will be presented.

Vienna Center for VLBI

The VLBI group at TU Wien operates the Vienna Center for VLBI in cooperation with the BEV.

The Vienna Center for VLBI has the capacity to conduct a complete VLBI experiment from scheduling to evaluation. For the scheduling of the experiment the in-house software VieSched++ can be used. After the experiment is observed, the correlator operated in Vienna is used to generate the observations. Finally, the observations are evaluated with the in-house developed software VieVS.

More on the Vienna Center for VLBI can be found at https://www.vlbi.at.

The Vienna VLBI contribution

The software VieVS was used to analyze the whole history of VLBI observations from 1979 to 2020. In total, more than 6000 sessions were analyzed. Fo the first time, the new fast VGOS antennas were included in the analysis.

A state of the art VLBI session analysis was performed with ITRF2014 (Altamimi et al. 2016) and ICRF3 (Charlot et al. 2020) as a priori coordinates. A priori EOP from the IERS EOP 14C04 (Bizouard et al. 2019) series were used.

The computed delay was estimated using models from the IERS Conventions 2010 (Petit & Luzum 2010).

The troposphere was estimated as zenith wet delays and gradients using PWLO. The estimation was conducted with a classic least squares approach with No Net Rotation (NNR) and No Net Translation (NNT) on datum stations and NNR on datum sources.

Non global parameters, such as troposphere, were later reduced from the normal equation system. The reduced normal equations were then sent to the combination center for further processing. Additionally, the normal equations were stacked in-house to create the Vienna CRF, TRF and EOP.

A couple of new models have emerged since the creation of ITRF2014. The following new modes were used in the analysis:

- New mean pole-tide model
- New HF-EOP model (Desai & Sibois 2016)
- Galactic aberration (MacMillan et al. 2018)
- Gravitational deformation of VLBI antennas (Artz et al. 2014)

Furthermore, the solution was calculated twice. Once with atmospheric pressure loading and once without. For the first time we also included baseline dependent clock offsets into our solution.

Why piecewise linear offsets?

PWLO are very flexible and allow the analyst to estimate parameters at a certain time interval. This is especially useful when lower intervals are interesting, for example when calculating sub daily EOP, zenith wet delays and so on.

The way it works is that offsets are estimated at a certain time interval and are related to the observation with a linear function between these offsets, see Figure 1.

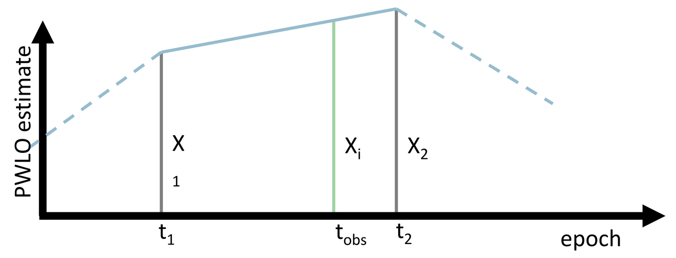

Figure1: Piecewise Linear Offset principle.

Vienna EOP parameterisation

The PWLO of the EOP must be chosen in such a way that they can be combined with solutions that use offset and rate.

The EOP are parameterized by choosing midnight as reference time and an interval of 48 hours for offset estimation. This makes sure that the 24 hour sessions are within the interval, which in turn results in a linear function across the session without any discontinuities within the time of the session. The slope of the linear function is controlled by introducing relative constraints. Weaker constraints allow the function to slope more and tighter constraints allow for less slope. This linear function is then equivalent to offset and rate.

For the Earth Rotation Parameter (ERP) the constraints are very weak allowing the function to slope across the session time.

The nutation is usually modelled as one offset without a rate. To realize this with PWLO, one has to use the same time interval of 48 hours but with very tight constraints, effectively constraining both offsets to the same estimate.

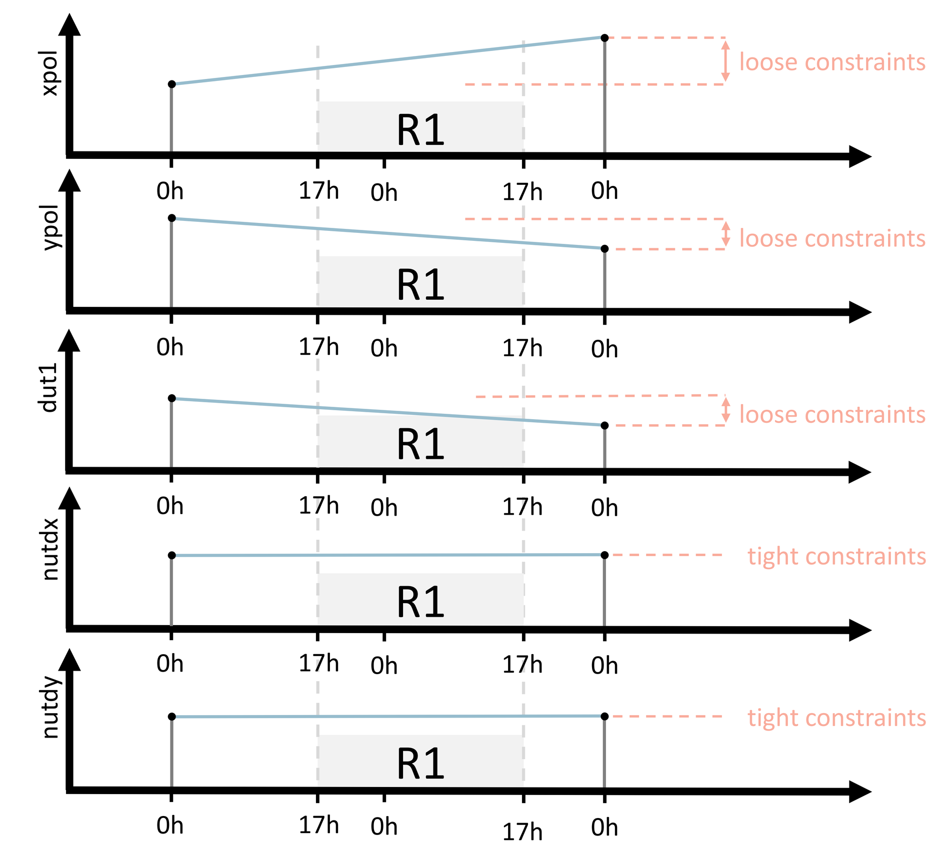

Figure 2: EOP parameterization used in the Vienna Solution. The parameterization was used to be equivalent with other analysis centers that use offset and rate for the ERP and only offsets for the nutation.

Combination

The individual solutions for each session and analysis center are submitted to the combination center, which is run by BKG. There the individual session solutions are combined with solutions from ten analysis centers. The final step is a global solution which is calculated by stacking the individual session solutions.

The Vienna solution was the only contribution, which used PWLO to model the EOP. All the other analysis centers modeled their EOP as offset and rate.

In order to combine the PWLO with offset and rate the combination center had to conduct a transformation of the normal equation system before stacking the solutions.

The EOP parameterization is only complete, when constraints are included, see previous section. Unfortunately, SINEX files are usually constraint free. This means that the important constraint information is lost and has to be communicated before using these files for the combination.

Figure 3 shows the WRMS of the ERP of all solutions with respect to the combined solution. The Vienna solution, denoted as VIE, is well within the average. It should also be noted that four of the analysis centers are using the CALC/SOLVE software, which gives these solution a bigger weight in the combination.

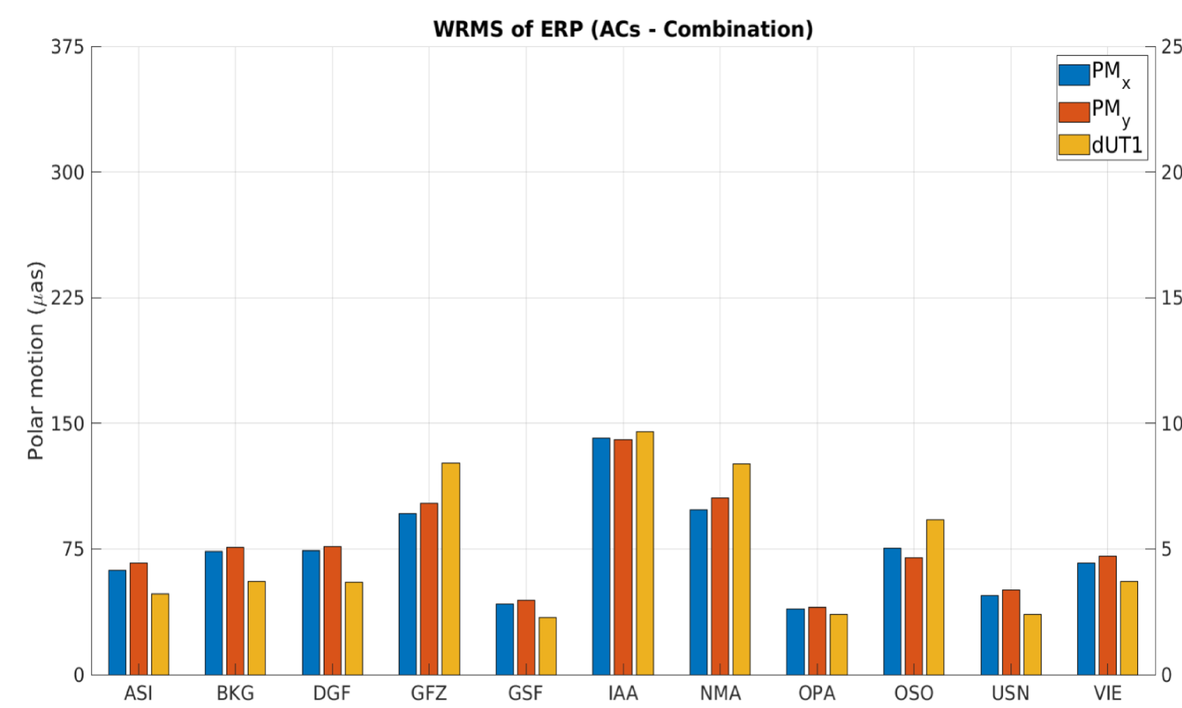

Figure 3: WRMS w.r.t. combined solution of all solutions submitted by IVS analysis centers. (Hellmers 2022)

The Vienna Solution

We also calculated our own global solution, where we estimated the TRF, CRF and EOP. In total the position and velocities of 108 stations and the positions of 5270 sources was estimated.

The Vienna only solution is in good agreement with the ITRF2020 (Altamimi et al. 2022). Figure 4 depicts the improvement of WRMS values of selected stations (stations that have significant changes) with respect to the ITRF2014. Negative values indicate an improvement to the older TRF. It is evident that the ITRF2020 (blue circles) and the Vienna TRF (red dots) are in good agreement with each other.

The Vienna TRF, CRF and EOP solution is freely available and can be downloaded from the Vienna Center for VLBI Website under: https://www.vlbi.at/index.php/products/.

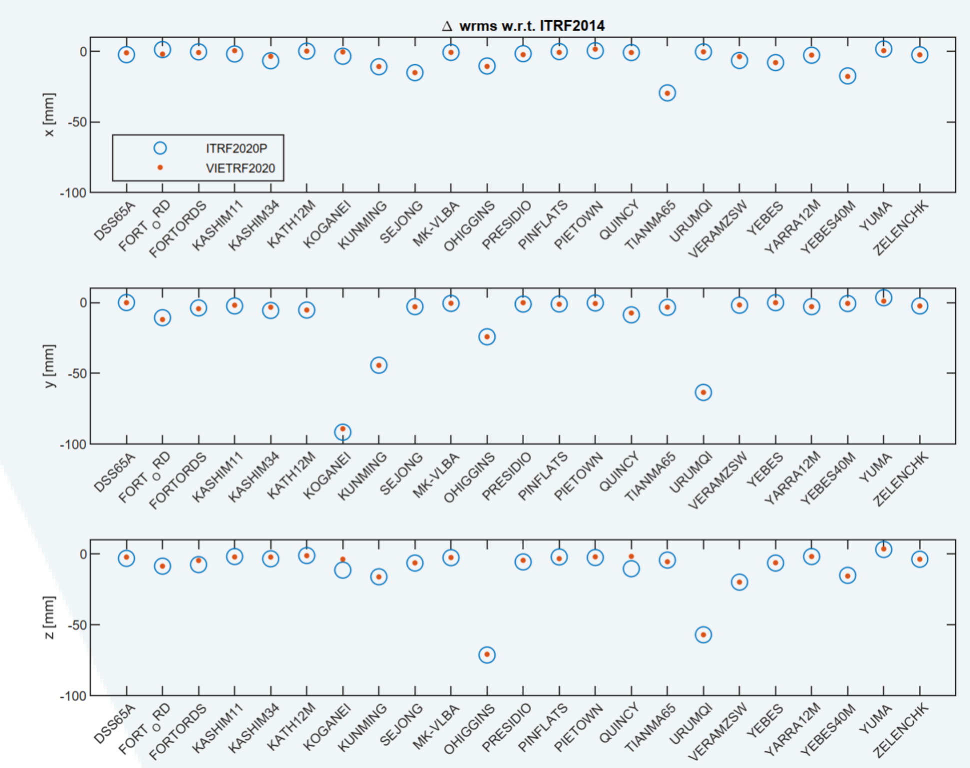

Figure 4: Difference in WRMS of ITRF2020 (blue circles) and Vienna solution (red dots) w.r.t. ITRF2014. Negative values indicate an improvement w.r.t. ITRF2014. Insignificant values (< 2mm) are neglected. (Krásná et al. 2022)

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